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L. O. HOWARD, Chief

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THE DESERT CORN FLEA-BEETLE.

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INTRODUCTION.

For a number of years past reports have been received by the Bureau of Entomology of considerable damage to corn, milo maize, and related crops by a small black beetle, *Chaetocnema ectypa* Horn, which, because of the fact that it is a native of the southwestern desert regions, has been named the desert corn flea-beetle (fig. 1, p. 5).

The writer first noted this small black beetle in the spring of 1910, while located on a ranch in the extreme southern part of California. In a field which had been planted to Indian corn, as an experiment on the productiveness of this corn in the newly irrigated Imperial Valley, it was noticed that within a few days after the corn came through the ground the leaves became whitened and bleached, apparently as a result of the work of some insect, and upon closer investigation this beetle was found to be the cause. Subsequently the work of this flea-beetle was noticed on various Egyptian corns and sorghums as well as on sweet corn in various localities, not only in southern California but also in southern Arizona and New Mexico.

The study of the habits, life history, and methods of controlling this insect was commenced in the Imperial Valley of California in 1910, and during 1913, 1914, and 1915 has been conducted at Tempe, Ariz,[1]

The following pages comprise a report of these studies and observations upon the economic status of this species in the Southwestern States.

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[1] The writer was assisted during a part of the time by Messrs. R. N. Wilson, F. H. Gates, and L. J. Hogg, of the Bureau of Entomology.

DISTRIBUTION.

So far as known, the distribution of this flea-beetle is confined to those areas of the southwestern United States that are normally semiarid in climate. As was stated in a preceding paragraph, the observations by the writer and his associates have been confined to California, Arizona, and New Mexico, and the species has been collected in practically all of the lower altitudes throughout these States. Collections in the higher altitudes show the species to be usually absent. This is no doubt due to the annual rainfall, which usually increases with the altitude. An exception to this rule, however, was found by Mr. F. H. Gates, during the fall of 1915, when he took several of the adult beetles at Prescott, Ariz., elevation 5,000 feet, where they were injuring Sudan grass. The writer, three months previous to this, had made observations throughout northern Arizona, stopping at Kirkland, Prescott, Ash Fork, Flagstaff, Holbrook, Williams, and Joseph City, all of which are located at altitudes over 3,000 feet, and although a careful and prolonged search was made upon various known food plants, not a specimen was found and no injury was apparent except at Prescott, where typical feeding scars were found on corn.

Through the kindness of Dr. F. H. Chittenden, the writer was permitted to make use of certain records in the files of his office and found that Prof. E. S. G. Titus had collected the species upon sugar beets at Lehi, Utah, and Huntington Beach, Cal.; that Mr. E. L. Crow found specimens at Yuma, Ariz.; and that Mr. H. O. Marsh collected specimens feeding upon corn at Anaheim, Cal.; the type specimens were secured at Los Angeles, Cal., and Dr. George H. Horn reported it as also occurring in Arizona. Only one other observation has apparently been recorded;[1] this was by Dr. A. W. Morrill, who mentions it as occurring upon Sudan grass at Phoenix, Ariz.

ECONOMIC CONSIDERATIONS.

To understand properly the nature of insect damage to crops growing on irrigated tracts in the southwestern semiarid regions of the United States one should know something of the existing conditions. A tract of land is often found, varying from 200 to 100,000 acres or more, entirely surrounded by thousands of acres of land which is practically worthless from an agricultural standpoint; yet growing upon this land are weeds and grasses which serve as the native food plants for certain insects. When this comparatively small irrigated or dry-farm tract is planted to any crop, such as corn, milo maize, Kafir corn, etc., a great many of these insects quickly attack the new growing crops and feed upon them. Then, when these crops follow one another year after year, and the area becomes established and known as a farming region, the insects develop in still larger numbers, being fostered by abundant food and protected by certain careless methods of farming. Sooner or later we have an economic pest of grave importance.

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[1] Morrill, A. W. Report of the entomologist of the Arizona Commission of Agriculture and Horticulture. Ariz. Com. Agr. Hort., 6th Ann. Rpt., p. 33, 1914.

The injury caused by the flea-beetle under discussion is due to just such circumstances, and to these alone.

As has been suggested previously in this paper, this insect does its greatest injury to Indian corn of various kinds and to the non-saccharine sorghums, while it bids fair to be a very important pest of Sudan grass. It also exerts a minor influence upon all crops on which it feeds, taking its yearly toll from each of them.

NATURE OF INJURY.

In destroying its food plant, this beetle works from both ends, as it were, the adults attacking the plant above the ground and the larvæ below the ground. The adults eat out the chlorophyll of the leaves, and when sufficiently numerous they cause the leaves to wilt. If feeding is long continued, new growing plants will be killed. As the eggs are deposited below the surface of the ground, the larvæ immediately begin feeding upon the roots, and soon the plant has quite a shallow root system that will not support it in a thrifty manner.

The roots, after having been injured by the larvæ, attempt to overcome this injury by sending out new laterals, as illustrated in figure 6, page 11, and then sometimes slight windstorms will cause plants to blow over and lodge badly, thus further reducing the yield.

EXTENT OF INJURY.

The extent of damage inflicted in any year upon any particular crop depends largely upon conditions. First, if corn is planted early in the spring, it will usually suffer most heavily. Then again, if the grain is planted under conditions which have been ideal for the hibernation of adult beetles, the damage will also be considerable. In the early months of the year sweet corn is especially liable to attack, and partly because of this it is almost impossible to secure roasting ears early.

Mr. Peterson, of the Bureau of Plant Industry, who was formerly in charge of the experiment station located at Bard, Cal., states that these beetles damage corn on the station plats to a considerable extent, and that they have caused this damage there for several years. The writer has seen small pieces of corn completely destroyed by this beetle, the attack occurring just as the corn was coming through the ground. In these cases the owner often thought that the corn had failed to come up.

Mr. R. N. Wilson, in notes made during May, 1912, at Sacaton, Ariz., relative to a small area cultivated by the Pima Indians, stated that corn on the Bureau of Plant Industry Experimental Farm at that place had been entirely killed by these beetles before it matured. Mr. Hudson, agent in charge of this farm, says that this is the usual fate of the early corn planted at Sacaton, but that some years the beetles are not so numerous and the corn partially escapes, although it is not so vigorous as it should be, on account of the beetle attack.

Three years previous to this, Mr. C. N. Ainslie, also of the Bureau of Entomology, made the following notes on his observations in the same locality:

> Heard early this a. m. that a "black bug" was destroying corn in garden. Found several long rows of corn 4 to 6 inches high, almost killed by *Chaetocnema ectypa.* The beetles were clustered on the leaves and in many cases a dozen or more would be down in the center, busy with the terminal leaf. The hills looked as if blasted by a hot wind.
>
> Some volunteer stalks of corn 2 feet high, in a watermelon patch some rods away, were bleached almost white, as was a plat of corn 2 feet high on experimental plat, 60 rods or so distant. These beetles are credited with doing much mischief to corn here.

Dr. A. W. Morrill[1] states:

> The corn flea-beetle, *Chaetocnema ectypa,* was unusually abundant in parts of the Salt River Valley, and was especially troublesome in experimental plots of Sudan grass at the experiment station farm near Phoenix.

Prof. G. F. Freeman,[2] of the University of Arizona Experiment Station, in speaking of variety tests of Papago and other varieties of sweet corn, says:

> Small black flea-beetles (*Chaetocnema ectypa*) injured both lots quite severely. So many plants of the early lot at Tucson were killed that all plots had to be replanted about April 20. The latter planting was injured to some extent but very few plants were killed outright.

From these observations it is obvious that the injury caused by this beetle is such as to demand careful attention, and vigorous efforts should be made to reduce its numbers upon the ranches of the southwestern United States.

FOOD PLANTS.

It seems probable that this beetle had as its native food plant some one or more of the native grasses growing in the Southwestern States, as it is found on quite a number of these. It is especially abundant at different times on wild barley (*Hordeum murinum*), salt grass (*Distichlis spicata*), Johnson grass (*Sorghum halepense*), and hair-grass dropseed (*Sporobolus airoides*), as well as on others. Johnson grass and salt grass are two of its favorite food plants, and at all seasons of the year when these grasses are flourishing the adult beetles can be found feeding upon the leaves, while the larvæ can be taken from the roots.

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[1] Morrill, A. W. Report of the entomologist of the Arizona Commission of Agriculture and Horticulture. *In* 6th Ann. Rpt. Ariz. Com. Agr. Hort., p. 33. 1914.

[2] Freeman, G. F. Papago sweet corn, a new variety. Ariz. Agr. Exp. Sta. Bul. 75, p. 462. May, 1915.

Of the cultivated crops, this beetle seems to be especially fond of corn, milo maize, and Sudan grass, and it is to these crops that it does the greatest damage. It has been taken in both the adult and larval stages, feeding upon Indian corn, milo maize, kafir corn, sorghum, sugar cane, Sudan grass, wheat, barley, and alfalfa, and Mr. R. N. Wilson reported it as doing exceedingly great damage to a field of beans on a ranch southeast of Tempe, Ariz. According to the statement of Mr. E. W. Hudson, many young bamboo plants growing on the Bureau of Plant Industry Experimental Farm at Sacaton, Ariz., were entirely killed. Dr. F. H. Chittenden has on file a record by Mr. E. L. Crow, showing that the beetle, besides feeding on corn, Johnson grass, and barley, occasionally attacks cantaloupes; and one by Mr. E. S. G. Titus, reporting it as feeding upon sugar beets

DESCRIPTIONS.

THE ADULT.

One is hardly likely to confuse this flea-beetle with any other occurring in the areas where corn, wheat, barley, and Sudan grass are seriously injured. Only one other resembling it in size, color, and jumping habits occurs in these semiarid regions in any number. This is the western cabbage flea-beetle (*Phyllotreta pusilla* Lec.) which occurs on cruciferous plants, and which differs in being slightly longer and in having a more pointed abdomen than the desert corn flea-beetle. The eastern corn flea-beetle (*Chaetocnema pulicaria* Crotch) occurs in

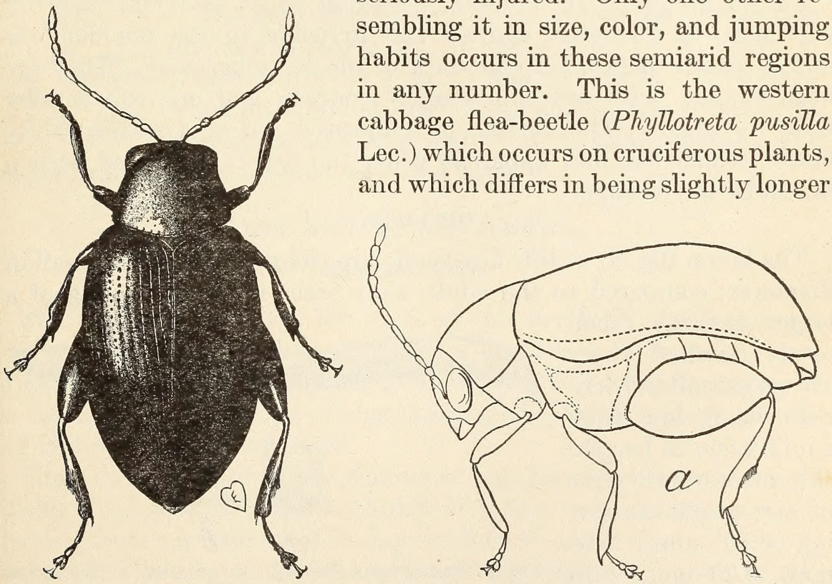

FIG. 1.—The desert corn flea-beetle (*Chaetocnema ectypa*): Adult, dorsal view; *a*, same, lateral view in outline. Greatly enlarged. (Original.)

exceedingly limited numbers in the southwestern United States, but the farmer need not be concerned in regard to this, for the insects are quite similar in habits and methods of control.

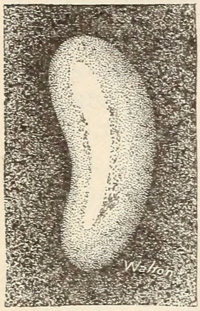
FIG. 2.—The desert corn flea-beetle: Egg. Greatly enlarged. (Original.)

The adults of *Chaetocnema ectypa* (fig. 1) are shining black, less than 2 millimeters (three thirty-seconds of an inch) in length, and nearly as broad as long. Upon a corn leaf they appear as tiny, nearly round objects, each about the size of the point of a lead pencil. The species was originally described by Dr. George H. Horn in 1899. His description is necessarily incomplete, since he merely points out the difference existing between *Chaetocnema ectypa* and *Chaetocnema obesula* Lec., which it very closely resembles. The description follows:

> Surface distinctly aeneous. Antennae rufotestaceous at base, the five outer joints piceous. Thorax distinctly alutaceous. The punctation extremely fine, indistinct, and sparse. The basal marginal line consists of fine, closely placed punctures. Anterior and middle femora brown, the posterior femora piceous, tibiæ and tarsi rufotestaceous. Length, 0.06 inch; 1.5 mm.

THE EGG.

The eggs (fig. 2) are minute, averaging about 0.35 mm. long by 0.15 mm. in diameter, whitish and invisible to the unaided eye unless placed upon a suitable dark or black background. They are bean shaped, with one side slightly concave and one end smaller than the other. The surface is sculptured and of a creamy white luster, which becomes apparent when the egg is examined with a binocular microscope.

THE LARVA.

The larvæ (fig. 3) of this flea-beetle are elongate and quite small in diameter; compared to the adult, they seem to be the young of a larger insect. When newly hatched they are very small and delicate, being less than a millimeter in length; the measurements of six specimens giving 0.80 mm., 0.75 mm., 0.70 mm., 0.75 mm., 0.80 mm., and 1.10 mm., they being eight times as long as their greatest diameter. The head plate measures 0.1 mm. in width. They are pale white excepting the head, which is a very light straw color, and are

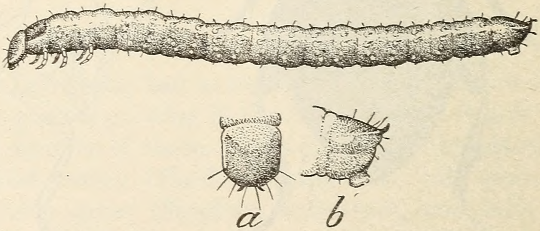

FIG. 3.—The desert corn flea-beetle: Larva; *a*, anal segment, dorsal view; *b*, same, lateral view. Greatly enlarged. (Original.)

partially covered with short stiff hairs. In color and texture they are so much like the corn roots in which they are found feeding that one will often overlook a larva, even with the aid of a microscope. However, when quite numerous, the full-grown larvæ are easily found on the roots of a corn plant or in the surrounding soil.

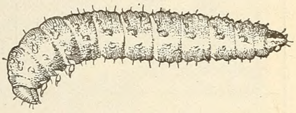
FIG. 4.—The desert corn flea-beetle: Prepupa. Greatly enlarged. (Original.)

The full-grown larvæ just previous to changing to prepupæ are often as much as 5 mm. (three-sixteenths of an inch) long, varying from 3.5 to 5 mm. in length; the average length being about 4 mm. They are opaquely white in color, well segmented, and cylindrical in form as compared with the younger larvæ.

THE PREPUPA.

The prepupa (fig. 4) is the full-grown larva which has shrunken preparatory to pupation, and is thus reduced to about one-half its former length, though it is considerably greater in diameter. It usually lies quietly, in a curved position resembling in shape a question mark. It is segmented and of the same texture as the full-grown larva.

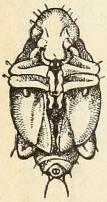
FIG. 5.—The desert corn flea-beetle: Pupa. Greatly enlarged. (Original.)

THE PUPA.

The pupa (fig. 5) very closely resembles the adult in size and appearance. It varies from 1.5 to 2 mm. in length and from 1 to 1.3 mm. in width. It is white when first formed, and has all appendages firmly compressed against the body. It is quite delicate, soft bodied, and sparsely covered with fine hairs.

LIFE HISTORY AND HABITS.

THE LIFE CYCLE.

The total length of the life cycle of this beetle in the Southwest averaged 46.3 days, with a minimum of 31 days in July and a maximum of 79 days in March, April, and May. This, of course, is subject to variation as in the case of most insects, and depends upon prevailing meteorological conditions.

The average length of the combined egg, larval, and pupal stages (Table I) of 82 specimens averaged 37.5 days for all temperatures, varying from a minimum of 24 days in June to a maximum of 65 days in March. Adding to this the average time required for the female to complete her development after issuing, before she deposits eggs, namely 9.8 days, gives the above-mentioned length of 46.3 days for the complete life cycle.

TABLE I.—*Combined length of egg, larval, and pupal stages of the desert corn flea-beetle (Chaetocnema ectypa) at Tempe, Ariz., 1915.*

Cage No.	Date adults placed in cage.	Date adults removed.	Average date of oviposition.	New adults emerged.		Combined length of stages.	Average mean temperature.
				Date.	No.		
						Days.	° *F.*
T 90	Mar. 12	Mar. 19	Mar. 16	May 13	2	58	64
T 91	...do....	...do....	...do....	May 6	2	51	64
				May 14	1	59	64
				May 20	2	65	64¾
T 92	...do....	...do....	...do....	May 13	3	58	64
				May 20	1	65	64¾
T. 117	Apr. 12	Apr. 19	Apr. 16	...do....	3	34	65
T 136	Apr. 26	Apr. 30	Apr. 28	June 10	2	43	71
				June 30	2	63	74⅓
T 137	...do....	...do....	...do....	June 26	2	59	73⅔
				July 3	2	66	75
T 170	May 25	May 27	May 26	June 26	2	31	79½
T 171	...do....	...do....	...do....	June 25	3	30	79½
				June 26	5	31	79½
				June 28	2	33	79⅗
				June 30	2	35	80
				July 3	4	38	80⅗
T 173	May 26	May 28	May 27	June 26	4	30	80
				June 30	2	34	80½
T 175	...do....	...do....	...do....	June 25	1	29	80
				June 26	3	30	80
T 193	June 21	June 24	June 22	July 16	4	24	84½
				July 17	2	25	84⅔
				July 20	2	28	84⅚
T 194	...do....	...do....	...do....	..do....	2	28	84⅚
				July 21	5	29	84⅚
				July 23	2	31	85
T 358	July 21	July 24	July 22	Aug. 23	2	32	86
				Aug. 24	6	33	86
				Aug. 25	3	34	86
T 359	...do....	...do....	...do....	..do....	3	34	86
				Aug. 26	1	35	86
Total and average	....	....	....	....	82	37.50	....

THE EGG.

The eggs are deposited at or near the surface of the ground, either on the stem of the host plant just below the surface of the ground, and within the soil, or, as was found by Mr. Wilson, on the old shell of the seed from which the plant germinated. They are usually deposited singly, but six or more may be placed at one location and at the same time. It was very difficult to make observations upon the natural place of oviposition under normal conditions because of the minuteness of the eggs and the consequent inability to see them unless the ground in which they were placed was very dark in color. In confinement beetles deposited eggs quite readily through cheesecloth upon any object which might be underneath, providing the surface of the object was kept moist. This fact was made use of in securing eggs, and cages (Pl. I, figs. 1, 2) were constructed with cheesecloth bottoms, having moist, dark-colored blotting paper beneath the cloth. The eggs, being deposited on the dark blotting paper, were easily counted and transferred to cages for records on the period of incubation.

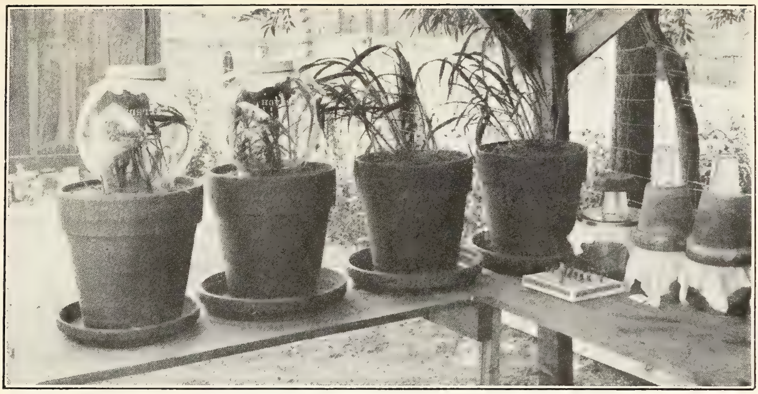

FIG. 1.—LABORATORY CAGES USED IN LIFE-HISTORY WORK ON THE DESERT CORN FLEA-BEETLE. (ORIGINAL.)

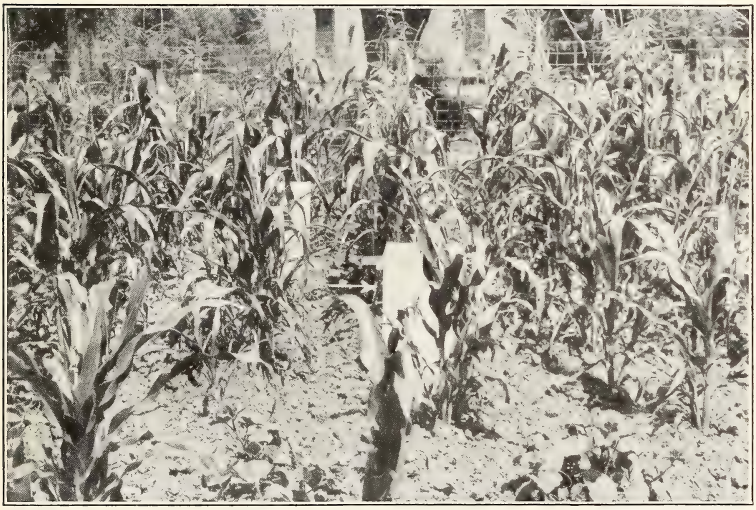

FIG. 2.—FIELD CAGES USED IN LIFE-HISTORY WORK ON THE DESERT CORN FLEA-BEETLE. (ORIGINAL.)

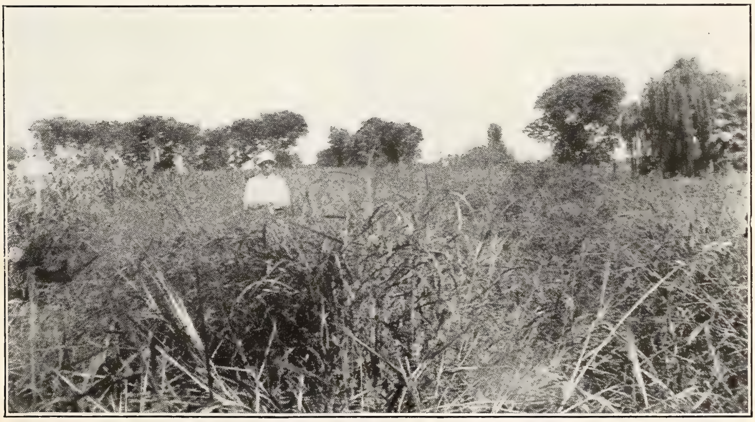

FIG. 3.—JOHNSON GRASS ALONG A NEGLECTED FENCE ROW AND DITCH BANK. A DEPLORABLE CONDITION FAVORING INSECT DEVELOPMENT AND AFFORDING A PLACE FOR INSECTS TO HIBERNATE. (ORIGINAL.)

THE DESERT CORN FLEA-BEETLE (CHAETOCNEMA ECTYPA).

The incubation period (Table II) varied from 3 days in the month of July and August to 15 days during March and April. The average time required for 314 eggs was 5.8 days. The egg stage was secured by placing freshly laid eggs within newly made plaster of Paris cages, the eggs being placed directly upon the plaster, which had been previously darkened with waterproof India ink. This plaster not only kept the eggs sufficiently moist, but also kept down any fungous growth until the eggs could have time to hatch. Just previous to hatching the eggs darken slightly, taking on a yellowish tinge, and the larvæ escape by bursting one side of the eggshell.

TABLE II.—*Length of egg stage of the desert corn flea-beetle (Chaetocnema ectypa) at Tempe, Ariz., 1913, 1914, 1915.*

Cage No.	Date laid.	Number.	Date hatched.	Number.	Length of incubation period.	Average mean temperature.
					Days.	°*F.*
	1913.					
B[1]	Aug. 27	23	Aug. 30	1	3	87
			Aug. 31	8	4	85
			Sept. 1	14	5	85
C[1]	Aug. 28	24	..do....	5	4	85
			Sept. 2	19	5	84.3
D[1]	Aug. 29	62	..do....	12	4	81
			Sept. 3	40	5	81
E[1]	Aug. 30	75	Sept. 4	35	5	81
H[1]	Sept. 7	36	Sept. 11	36	4	87
L[1]	Sept. 19	5	Sept. 22	5	3	83
M[1]	Sept. 29	6	Oct. 6	5	7	71
	1914.					
2	Feb. 27	20	Mar. 12	20	13	61
3	Mar. 18	30	Mar. 28	17	10	64
			Mar. 29	6	11	63.5
			Apr. 1	3	14	62.6
4	Mar. 20	15	Apr. 3	1	14	61
			Apr. 4	7	15	61
	1915.					
T 141	May 22	25	May 27	25	5	74.6
T 163	June 12	25	June 17	25	5	80
T 239[2]	July 13	22	July 16	6	3	86
			July 17	16	4	86
T 360[2]	July 22	23	July 25	8	3	85
Totals and average	....	391	....	314	5.8	....

[1] R. N. Wilson's records.

[2] L. J. Hogg's records

THE LARVA.

DURATION OF LARVAL PERIOD.

It was quite easy to secure the approximate length of the larval stage of many specimens, but owing to the feeding habits, a great deal of difficulty was experienced in securing the exact length of this stage. Various types of cages were first tried, all of them embodying the feature that the larvæ must be beneath the surface of the ground in order to insure their reaching maturity. In the past two years, however, the experiment was modified by placing the newly hatched larvæ upon small tender sections of corn root, within the cavity of plaster of Paris cages, consisting of 2 or 3 ounce salve boxes filled with newly mixed plaster in which a cavity was bored before the plaster had set. The first season that these cages were used a great many larvæ were reared partially but died before reaching maturity. Finally efforts in this direction were rewarded and six larvæ were carried successfully through from egg to pupa (Table III) during the month of June at a mean temperature of 84° F., and during this time the length of the larval stage averaged from 22 to 25 days.

TABLE III.—*Length of larval stage of the desert corn flea-beetle* (*Chaetocnema ectypa*) *at Tempe, Ariz., 1915.*

Date egg hatched.	Date of pupation	Length of larval stage.	Average mean temperature.
		Days.	°*F.*
June 17	July 9	22	84
Do....	...do.....	22	84
Do....	...do.....	22	84
Do....	July 10	23	84
Do....	July 12	25	84
Do....	...do.....	25	84

However, since little difficulty was experienced in securing the respective lengths of the egg and pupal stages, and then the sum of the lengths of the egg, larval, and pupal stages, it was possible from these data to obtain the length of the larval stage by subtracting the sum of the egg and pupal stages from the sum of the three stages. Thus we had the approximate length of the larval stage during practically every month in which these beetles were developing. It may be seen by consulting Tables I and III that this approximate length of the larval stage, under periods of the same temperatures, compares favorably with the exact length of the stage as noted in the case of the six larvæ mentioned. By the latter method the larval stage is found to vary from 20 days in the warm summer months to 47 days during the cooler months of the season, an average length for the larval stage of about 32 days for all temperatures.

FEEDING HABITS OF THE LARVA.

Quite soon after hatching the young larva begins eating its way into the tender succulent roots of the host plant. It thus constructs a tunnel for itself as it feeds, and soon disappears from sight. Usually the boring of the larva occurs in the cortex. On the roots of corn (fig. 6) the tunnel will often appear to be formed between the cortex and the stele or central cylinder. The reason for this attack on the cortex first is doubtless because it is more tender than the rest of the root. If the feeding be of prolonged duration the entire root may be tunneled. Many of the roots are entirely hollowed out by these "feeding mines," while in others the feeding may produce a groove along one side of the root, the larva finally entering the root and the tunnel being continued within the same. Often where two tunnels pass, the root is entirely cut off, and as is the case with small fibrous roots, they are often entirely consumed. This feeding habit frequently makes it quite difficult to locate any larvæ except those that were completely matured, and hence they were usually found in the soil at some distance from the root. The larvæ consume a considerable amount of food. A single larva confined in a plaster of Paris cage entirely consumed a section of root one-fourth of an inch long and one-sixteenth of an inch in diameter.

LARVAL FOOD PLANTS.

The food plants of the larvæ do not differ materially from those of the adults. The amount of damage done to these various food plants does, however, differ considerably as between the larva and adult. Alfalfa is rarely, if ever, injured by the adults, while the larvæ do a considerable amount of damage to alfalfa roots, especially in alfalfa fields which have been seeded to a grain crop such as barley, oats, or wheat during the winter. It is upon corn, however, that the larvæ do their greatest damage. This is, of course, due to the fact that the feeding of the adults is concentrated upon newly growing corn each spring, and egg deposition consequently becomes much heavier, the resulting damage being accordingly great.

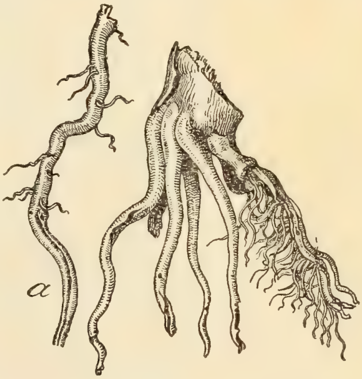

FIG. 6.—Section of corn root showing injury by larvæ of the desert corn flea-beetle. About one-half natural size. (Original.)

THE PREPUPA AND PUPA.

When the larva becomes full grown it constructs an oblong earthen cell in which to change, (1) to a transitional or prepupal stage, and (2) after a further period of a few days, to the true pupal stage. These pupal cells average about three-thirty-seconds of an inch in length, the inner walls being quite smooth. In constructing its cells the larva, owing to the fact that it is longer than its cell, must be doubled back upon itself, thus working in very close quarters. As soon as the cell is completed the larva changes to a prepupa. In this stage the body length shrinks while the diameter greatly increases, and the larva changes to a plump, rotund object shaped like a question mark. This stage, as shown by Table IV, varies in length from 2 to 8 days, the average being 3.4 days for 10 specimens. This was ascertained by taking larvæ that had already constructed their pupal cells, placing them in a vial, and allowing them to go through these various changes in plain sight.

TABLE IV.—*Duration of prepupal and pupal stages of the desert corn flea-beetle* (*Chaetocnema ectypa*) *at Tempe, Ariz., 1915.*

Pupa No.	Date prepupa formed	Date of pupation.	Length of prepupal stage.	Date adult issued.	Length of pupal stage.	Average mean temperature.
			Days.		*Days.*	° *F.*
1	Apr. 30	May 6	6	May 13	7	70
2	...do	...do	6	...do	7	70
3	May 8	May 10	2	May 14	4	76
4	May 10	May 12	2	May 17	5	75
5	...do	...do	2	...do	5	75
6	...do	...do	2	...do	5	75
7	Apr. 27	Apr. 29	2	May 11	12	68
8	...do	May 5	8	May 13	8	70
9		May 7		...do	6	70
10		...do		...do	6	70
11		May 8		May 14	6	73
12		...do		...do	6	73
13		...do		...do	6	73
14		May 10		...do	4	76
15		May 10(5)		May 15(5)	5	75
16		May 11		May 17	6	75
17		...do		...do	6	75
18	July 15	July 17	2	July 20	3	86
19	...do	...do	2	...do	3	86
Average of 23 pupæ			3⅖		5⅔	

The duration of the pupal stage, which was determined in the same way, was found to vary from 3 to 12 days, with an average of 5⅔ days (Table IV). In a dry soil the larvæ pupate at as great a depth as 4 inches below the surface, while in an extremely moist soil the pupal cell is often formed within one-fourth to one-half inch of the top of the ground, and in one rare instance it was found at the surface of the ground just beneath some decaying vegetable matter. It can thus be readily understood that a pupa near the surface of the ground would receive more heat from the sun's rays, and consequently would develop more rapidly than one at a greater depth. This fact doubtless explains some of the variations in the combined lengths of the egg, larval, and pupal stages in some cages, the records of which appear in Table I. For instance, in cage T–136 the combined lengths of stages are shown to vary from 43 to 63 days, and in cage T–117, with a mean temperature 5 degrees lower, adults were secured in 34 days It is obvious that this presents a vulnerable point for attack in the life of this pest, for if corn is well irrigated the pupæ will be formed near the surface of the ground, and then if each irrigation is followed by a careful, close but shallow cultivation, a goodly percentage of the pupæ are exposed to the sun and the drying effects of the air, and hence killed.

THE ADULT.

The change from pupa to adult takes place rather quickly, but often a day or two passes before the adult entirely assumes the characteristic shining black. When the adults first emerge from the pupal state they are almost white, but after a short time gradually become darker, beginning with the legs, then the elytra, and finally the whole body is enveloped.

The adults are very soon able to jump nimbly and it is this habit which has given this group their name of "flea-beetles." They are quite easily alarmed, leap quickly from a plant, and, falling to the ground, often feign death in order to escape their enemies.

To the ordinary observer the males and females are very much alike, the difference being largely one of size, the male averaging slightly smaller than the female. A gravid female can be distinguished by the size of her abdomen, but large males are often larger than small females, so that the distinction is not very reliable.

ADULT DEVELOPMENT.

After the adults emerge several days must elapse before their sexual development is completed. Numerous records on this point were made by the writer as well as by J. H. Newton, assistant in the bureau at Tempe, and it was found that copulation usually takes place from 4 to 6 days after emergence and oviposition from 4 to 5 days thereafter. Table V shows the length of the period elapsing from issuance to oviposition as observed in five females. This varied from 7 to 14 days, the average being 9.8 days.

TABLE V.—*Length of life of the desert corn flea-beetle* (*Chaetocnema ectypa*) *at Tempe, Ariz., 1915.*

Date adult issued.	Date oviposition began.	Age at beginning of oviposition.	Adult died.	Length of life.
		Days.		*Days.*
On or before Apr. 25	Apr. 29	....	June 1	38+
On or before Apr. 20	Apr. 28	....	May 31	41+
May 7 (3)	May 22	14	May 27	20
May 17	May 26	9	June 15	29
Do	May 29	12	...do.....	29
July 16	July 23	7	July 31	15
Do	July 25	9	...do.....	15
On or before Apr. 28	May 7	....	July 20	83
Average	....	9.8	....	33.6

NUMBER OF EGGS DEPOSITED BY ONE FEMALE.

The females usually lay their eggs in stages, there being from one to two, and sometimes three, different egg-laying stages, often extending over half a month. As shown in Table VI, a female may deposit all her eggs in a single day, or in two or more successive days, or she may deposit only a part of them and then rest from four to five days, after which another large number may be deposited; then, after another period of three or more days, a third deposition of eggs may occur.

TABLE VI.—*Egg-laying record of 13 females of the desert corn flea-beetle* (*Chaetocnema ectypa*) *at Tempe, Ariz., 1915, by L. J. Hogg.*

Female No. 8	18	13	0	1	1	0	10	0	0	16	....	....	....	....	....	....	....
Female No. 7	11	0	0	13	0	0	0	0	0	1	0	0	0	0	0	0	11
Female No. 10	1	1	6	0	0	0	0	31	0	1	....	....	....	....	....	....	....
Female No. 5	22	0	0	0	0	1	....	....	....	....	....	....	....	....	....	....	....
Female No. 12	16	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Female No. 14	3	0	2	12	4	0	0	10	7	13	0	1	1	0	4	0	28
Female No. 15	5	0	0	6	12	0	36	0	0	0	0	15	0	5	0	22	....
Female No. 6	1	3	1	4	28	0	21	11	....	....	....	....	....	....	....	....	....
Female No. 16	5	0	0	8	7	....	....	....	....	....	....	....	....	....	....	....	....
Female No. 1	8	0	0	1	0	5	1	0	12	0	0	0	0	0	0	14	4
Female No. 4	1	0	12	0	14	0	3	0	6	0	0	0	19	....	....	....	....
Female No. 9	23	0	0	0	0	0	0	10	0	30	0	0	15	33	0	0	15
Female No. 11	6	0	4	0	13	0	0	3	6	....	....	....	....	....	....	....	....

NOTE.—This table shows the record of a female from the day she started oviposition until the day she finally completed the same and does not show her length of life, either before or after oviposition.

The females are quite prolific, often laying from a dozen to over 100 eggs each. During June of 1915 the writer recorded four females which laid, respectively, 19, 57, 20, and 29 eggs, while three females, all confined in the same cage, laid a total of 145 eggs, averaging 48 eggs each in a period of 12 days. Mr. L. J. Hogg during August of the same year made oviposition records upon 16 females which he had under observation, the number of eggs for each female being as follows: 23, 40, 85, 101, 69, 20, 45, 11, 55, 17, 126, 36, 39, 25, 23, 14.

LENGTH OF LIFE.

In cages the adults usually died within a week or 10 days after oviposition was completed, but in some cases the length of life of the adult beetles was often prolonged. As shown in Table V, it varied from 15 to 83 days, the average for these eight specimens being 33.6 days.

It is suspected that in the field, under natural conditions, where they are better able to protect themselves from the sun and from the moisture which was nearly always more or less present in small vial cages, the length of life might be even longer than that recorded in this table.

METHODS OF FEEDING.

The adult beetles usually feed during the cooler parts of the day in the warm summer months and during the warmer parts of the day in the cooler spring and fall months. During the summer they protect themselves by getting down within the infoliations of the plants, where they may secure tender succulent food and at the same time be protected from the heat. In feeding a beetle will stand crosswise on a corn leaf and with its strong mandibles eat out a portion of the epidermis between two parallel veins, continuing in a straight line, often 1 or 2 inches in length. They rarely eat a hole entirely through a leaf. In cases where extremely heavy feeding occurs and where the infestation is great, the green portion is entirely eaten out, and the leaf has a burned or scarred appearance.

SEASONAL HISTORY.

NUMBER OF GENERATIONS ANNUALLY.

The desert corn flea-beetle usually appears about the middle of February each spring. The time at which the beetles may first be found actively feeding in the field will, of course, depend upon the season. In the year 1912 Mr. R. N. Wilson first took these beetles on February 14, sweeping a few specimens from a barley field. In 1913 the same observer took a few feeding beetles on January 13. The month of January of that year, however, was quite warm and advanced over the ordinary year. In the year 1914 Mr. D. J. Caffrey took adults for the first time on February 20. These were feeding in a green wheat field. In the spring of 1915 Mr. F. H. Gates first swept adults in an alfalfa field on February 9. They did not, however, become abundant until February 23, when both the author and Mr. Gates secured an abundance of this species.

It is only a few weeks after emergence that these hibernating adults begin depositing eggs. The earliest date that eggs have been secured in cages was March 12, 1915, at which time the writer secured eggs in considerable numbers. There are from three to four generations each year in the Salt River Valley. The first generation, starting with eggs deposited in early March, appears about the first of June. Another generation quickly follows, adults coming forth about the middle of July, a third generation is completed by the first to the middle of September, and in occasional years there is a partial fourth generation.

The fact, however, that the length of each individual life cycle is determined quite largely by the proximity of both larvæ and pupæ to the surface of the ground is responsible for the general intermingling of the various generations, so that eggs may be secured throughout the breeding season. Eggs have been secured in cages throughout the year, beginning with the first of March and continuing to the middle of October. Mr. Wilson has secured eggs in cages during the months of May, June, July, August, September, and October, while the writer has secured eggs during March, April, May, and June, and these records were followed up by those of Messrs. Hogg and Newton, who obtained eggs during July, August, and September of the same year. Of course, eggs deposited the first of October would, ordinarily, not reach maturity, while those deposited in the middle of September in some seasons develop a partial fourth generation. From October 13, 1914, to March 9, 1915, the writer maintained in a laboratory cage a large number of Chaetocnema adults which had been collected from the field, but did not secure a single egg during this time.

HIBERNATION.

From the foregoing remarks on the generations it is at once seen that these adults usually are found hibernating during the latter part of November, in December, and in January. They enter hibernation gradually during November, and one is rarely able to find adults throughout December and January, although on an occasional warm day specimens might be secured during any winter month. On Nov. 7, 1912, at Tempe, Ariz., Mr. R. N. Wilson made the following note:

> Only a few Chaetocnema could be found on corn on the Godfrey field to-day.

Then on November 23, 1912, he made the following observation:

> The corn on the Godfrey field has been cut since the field was last visited. No specimens were found.

On December 14, 1914, also at Tempe, the writer observed adults in hibernation and made the following record:

> A few Chaetocnema adults were found to-day in protected places, as back of sheath leaves, in an old cornfield, and at the base of wild barley plants that thickly covered the ground. The species is apparently very quiet at this time and can be said to be hibernating. The past week has been rather cold and several mornings the temperature fell to considerably below freezing. One or two specimens were noted, however, that appeared quite active.

The hibernating adults may be found beneath anything that will give them protection, such as rubbish and grass clumps in waste places. A favorite place for adults to winter is along ditch banks thickly grown up with Bermuda and Johnson grass. These places seem to be ideal because, late in the winter or early in the spring, they become overgrown with wild barley, and this plant gives the beetles succulent food the first warm days in the spring. Waste salt places which are not too wet and are grown up with salt grass also afford ideal conditions for hibernation quarters, and the beetles have been observed on this grass quite early in the spring. Early in 1912 Mr. R. N. Wilson made the following note:

> At the northeast corner of this farm there is a large patch of salt grass (*Distichlis spicata*), which forms a thick mat on the ground. Sweepings made on this grass to-day revealed many Chaetocnema. This is likely one of their food plants, and probably furnishes an ideal place for hibernation.

NATURAL ENEMIES.

Judging from our present knowledge of this species, it seems to be fairly free from the attacks of enemies of any kind. While it is quite possible that it is occasionally picked up by birds, yet no definite observations have ever been made upon this, and the Bureau of Biological Survey has no records bearing upon this species, though related species have been found to be taken as food by certain birds.

PREDACIOUS ENEMIES.

The larvæ of this beetle are without doubt fed upon by several subterranean larvæ of ground beetles which have been found to inhabit the soil in the vicinity of corn plants. The adults are preyed upon by the nymphs and adults of *Reduviolus ferus* L. Mr. Wilson first took specimens of these nymphs, which be found feeding upon Chaetocnema adults, at Tempe, Ariz., and reared them to maturity, and then found that both adults and nymphs were feeding upon the flea-beetles. It is quite likely that other reduviids also attack this species.

At Holtville, Cal., the writer found a great many beetles with their bodies almost covered by a species of mite: Upon being sent to Washington these mites were determined by Mr. Nathan Banks as *Pediculoides* sp. They have since been found quite frequently upon adult flea-beetles.

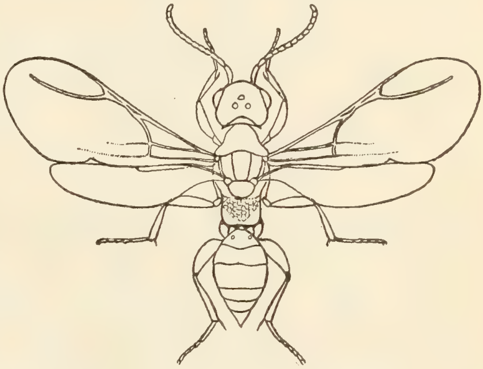

Fig. 7.—*Neurepyris* sp., a parasite of the desert corn flea-beetle. Greatly enlarged. (Original.)

PARASITIC ENEMIES.

During his observations in 1915,[1] the writer discovered that a small parasitic wasp, *Neurepyris* sp.[2] (fig. 7), was preying upon the larvæ and prepupæ of this flea-beetle. Six specimens taken in the soil, already within the pupal cases, were each found to have very small, insignificant external larvæ feeding upon them, the larvæ being attached to the ventral side just back of the hind pair of legs. These were carefully placed in small vials, and subsequently several of the parasites died, while one specimen pupated and finally changed to an adult, the hymenopterous larvæ in the meantime having completely consumed the beetle larvæ.

The adult of this parasite is very small, black, with yellow legs, and its pupal case, which is about the size of a Chaetocnema pupa, is constructed in the soil of a brown, densely woven material. The larval stage of this parasite was found to be about 8 days and the pupal stage 24 days. This was during the month of May, with the mean temperature about 76° F.

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[1] At Tempe, Ariz.

[2] Determined by Mr. S. A. Rohwer.

REMEDIAL AND PREVENTIVE MEASURES.

The control of this insect over a wide area can be accomplished only by cultural methods, the eradication of its hibernation quarters, and the destruction of some of its favorite native and adopted grass and weed food plants. In smaller areas, consisting of only a few acres, a certain degree of success can be expected from the use of arsenate of lead as a spray. Several experiments were tried, using different kinds of repellents, but without any great amount of success.

The greatest damage is done to the plant just as it is coming through the ground, because at this time it is more tender and attractive to the beetles and also is less resistant to insect attack. If, therefore, the growth of the plant is stimulated by good cultivation, fertilizers, or any other stimulative measures, as has been recommended by Mr. Wilson in his notes upon this species, then the plant will have an excellent chance in spite of the flea-beetles. If the numbers of the beetles are also lessened by the cleaning up of hibernation quarters and the eradication of breeding places, the plants will have a still greater chance of reaching maturity, and finally, if the plants are sprayed by arsenate of lead, as will be shown later, the damage will be almost negligible.

REPELLENTS.

While located on a ranch south of Holtville, Cal., in April, 1910, the writer undertook to determine the value of several volatile oils and also of naphthalene balls, as repellents for this beetle. The oils used were those of eucalyptus, citronella, and pennyroyal. A small piece of cotton was placed in the ground, even with the surface of each hill of corn treated, and was moistened with the oil each morning for five days, while the naphthalene balls were utilized by placing a single ball beside a hill of corn. Two rows were treated with each of the four remedies used and every third row was left untreated as a check row, the idea being that if the corn could be protected for a few days it would reach a stage of growth in which it would be able to withstand an attack from the flea-beetles. The results of this experiment may be summarized as follows: The naphthalene balls and the oil of eucalyptus were found to act in no way as repellents of this beetle. The rows treated with the oil of citronella were damaged the least by the flea-beetles, while the rows treated with the oil of pennyroyal were damaged only slightly. However, since the cost of these oils and the time taken in application were found to be prohibitive from an economical standpoint, and since the results were not conclusive, the use of these repellents can not be recommended.

POISONS.

Speaking in regard to the control of this flea-beetle on Sudan grass, Dr. A. W. Morrill[1] states:

> Experiments with applications of Bordeaux mixture and arsenate of lead to the infested grass failed to give satisfactory results.

Later than this, after additional experiments, he remarks:[2]

> Spraying the plants with arsenate of lead, using one ounce of arsenate of lead powder to one gallon of water, is the only remedial measure which can be recommended at the present time.

Prof. Freeman,[3] in his bulletin previously mentioned, speaking of the injury from this little flea-beetle, says:

> The plants were all sprayed twice with lead arsenate, but very little benefit could be ascribed to this treatment.

In correspondence with Prof. Freeman, the writer was informed that he used arsenate of lead without soap in the solution, and he says that the spray collected in drops upon the corn foliage, and attributes the failure of the arsenate of lead to this fact.

The writer first used 1 pound of powdered arsenate of lead to 50 gallons of water, but without any success whatever, the beetles being fully as numerous on rows treated as on those not treated. It was easily seen that this was due to the fact that the solution of arsenate of lead did not stick to the corn leaves. Later an experiment was tried, using powdered arsenate of lead, 2 pounds to 50 gallons of water, mixed in a strong soap solution which caused the diluted poison to stick well to the surface of the leaf. This seemed to act both as a repellent and as a poison to the beetles, and the treated rows were in no way injured by the attack of these flea-beetles. While additional experiments must be carried on with regard to the use of this poison, from the writer's past observations it can be used in this manner upon small areas of corn, applied by means of a small spray pump, with very satisfactory and practical results.

CULTURAL METHODS.

As has been pointed out in the discussion of the pupal stage of this flea-beetle, if the soil be kept fairly moist the pupæ will form near the surface of the ground and within 2 or 3 inches of the corn plant. Now, if precautions are taken to follow each irrigation by a very shallow cultivation close to the plant and shallow enough to insure no tearing of the root surface, a great many pupæ will be destroyed and damage to future crops will be greatly lessened. Such cultivation will not only assist in reducing the number of beetles maturing, but it will also aerate the ground and place it in a thrifty condition, producing strong healthy plants that will be able better to withstand insect attacks.

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[1] Morrill, A. W. Report of the entomologist of the Arizona Commission of Agriculture and Horticulture. Ariz. Com. Agr. Hort., 6th Ann. Rpt., p. 33, 1914.

[2] Morrill, A. W. The Corn Flea Beetle. *In* Ariz. Agr. Exp. Sta. Bul. 75, p. 468. May, 1915.

[3] Freeman, G. F. Papago sweet corn, a new variety. Ariz. Exp. Sta. Bul. 75, p. 462. May, 1915.

This point should not be passed without mention of the fact that stable and barnyard or corral manure, which, in the Salt River Valley, is ordinarily dumped in waste places, on ditch banks, or absolutely destroyed, as it were, should be utilized in building up the soil and making it still more productive than it is at the present time. Manure is ordinarily not used in the warm southwestern country because it is claimed that it causes burning of the plants and contributes to the dispersion of weed seeds. If manure is thoroughly rotted and properly applied it will not burn the plants, and if rotation of crops is practiced, there will be a minimum of complaint in regard to the dissemination of weed seeds.

Mr. E. W. Hudson, who has been in charge of the Bureau of Plant Industry Experimental Farm at Sacaton, Ariz., and who is well acquainted with farming conditions in the Southwest, believes that all manure should be utilized, and if it is to be plowed under it should be applied in the fall, turned under, and given a chance to decay during the cool part of the year. If used at other times of the year, he believes that it should be applied by the aid of a manure spreader as a light top-dressing. The writer is thoroughly in accord with this latter method, for in addition to putting the nourishment just where it is needed by spreading the manure over the ground where it soon dries, the breeding of flies is also avoided. If all manure and refuse were handled in this manner, there would be a considerable reduction in the fly population of these regions.

If land well treated with stable manure is afterwards planted to corn, the plants will be enabled to make a good start and continue in a thrifty condition in spite of flea-beetle attack.

ERADICATION OF JOHNSON GRASS AND OTHER TROUBLESOME GRASSES.

Since it has been shown that this flea-beetle lives quite largely upon Johnson grass (*Sorghum halepense*) and salt grass (*Distichlis spicata*), it is obvious that the fewer of these grasses found growing in alfalfa fields or cultivated fields of any kind and also along roadsides and ditch banks, the fewer the number of beetles to attack the cultivated crops. While Johnson grass may be a difficult and troublesome grass to control, yet there is no excuse for allowing it to become an almost inaccessible thicket, 15 to 20 feet wide, along roadsides, fence rows, and ditch banks, as is sometimes found to be the case in Arizona. Each farmer should consider it a part of his duty to the community in which he lives to mow such places two or three times a year, or to pasture them with sheep, thus keeping down all weed and grass growth.

ELIMINATION OF HIBERNATION QUARTERS.

Cleaning up weeds and grasses will eliminate a great many of the hibernation quarters of this beetle, and if such methods can be carried further, to include all waste places and any place where trash may accumulate, then the hibernating beetles will not be able to protect themselves from the colder days and frosty nights of the winter months and their numbers will be reduced.

SUMMARY.

The desert corn flea-beetle is present in injurious numbers in the cultivated areas of the southwestern United States, where it takes an annual toll upon such crops as corn, milo maize, sugar cane, Sudan grass, wheat, barley, and alfalfa. Both the adults and the larvæ are concerned in injuring crops, the adults feeding upon the top of the plant and the larvæ upon the roots.

The eggs are deposited at or near the surface of the ground and hatch in about six days. The young larvæ are found within the tender roots of the food plants, while the older larvæ are found in the soil near these roots. The average length of the larval stage is found to be 32 days.

The prepupal and pupal stages are both passed within a cell in the soil near to the roots on which the larvæ fed.

The flea-beetles hibernate in the adult stage under rubbish or at the base of various grasses growing in the regions of infestation.

The total length of the life cycle of this flea-beetle is about seven weeks, there being from three to four generations each year.

The numbers of adult flea-beetles can be reduced greatly by cleaning up hibernation quarters and eradicating some of their weed food plants, such as Johnson grass, salt grass, and Bermuda grass. They can be further reduced by carefully cultivating such crops as can be cultivated just as soon as the soil becomes dry, following each irrigation. This method destroys a great many pupæ. Small pieces of corn can be sprayed successfully with arsenate of lead, using 2 pounds to 50 gallons of water, the water being made into a strong soap solution. This acts both as a repellent and as a poison to the beetles.

Injury to corn and other crops can be overcome partially if the soil is placed in the best possible cultural condition by the addition of barnyard manure or other fertilizer.

The nymphs and adults of a predacious hemipteron (*Reduviolus ferus* L.) were observed to feed upon these beetles, and a small parasitic wasp, *Neurepyris* sp. (fig. 7.), was found to prey upon the larvæ and prepupæ.

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